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Ben-Tzur et al.

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(45) **Date of Patent: Nov. 16, 2010**

(54) **PRE AND POST-HARVEST QC DATA ACQUISITION SYSTEM FOR AGRICULTURAL PRODUCTS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 717 days.

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PCT Pub. Date: **Dec. 9, 2004**

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Related U.S. Application Data

(60) Provisional application No. 60/474,692, filed on May 29, 2003.

(51) **Int. Cl.**
G06F 19/00 (2006.01)

(52) **U.S. Cl.** **702/188**

(58) **Field of Classification Search** 702/188, 702/182–185, 130
See application file for complete search history.

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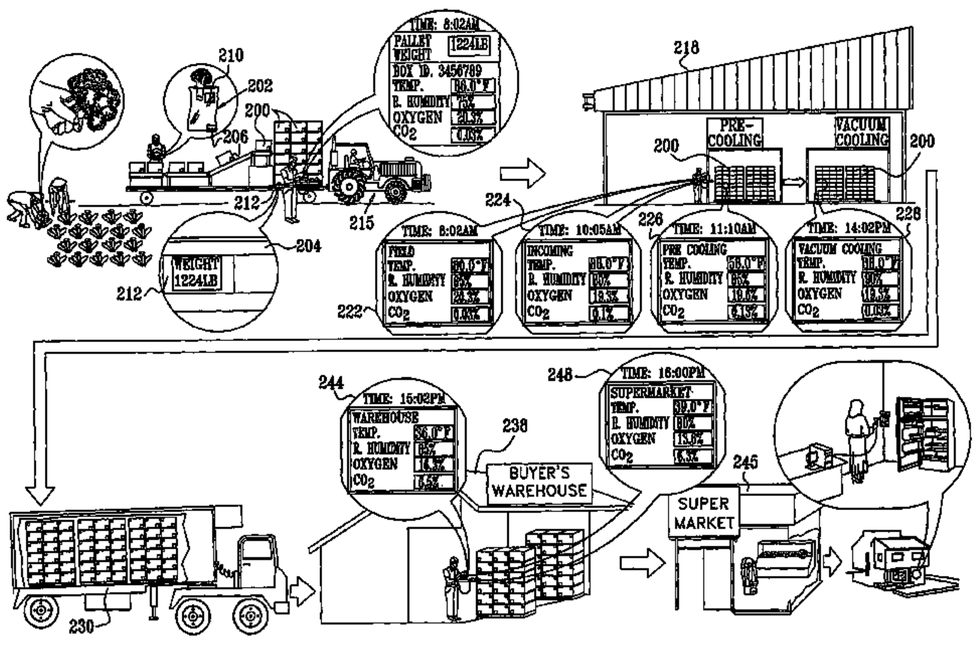
Primary Examiner—Edward Raywond
(74) *Attorney, Agent, or Firm*—Ladas & Parry LLP

(57) **ABSTRACT**

A system for monitoring parameters of produce including at least one sensor assembly for sensing at least one parameter of packaged produce at a plurality of times and locations of the packaged produce; a communications network operative to receive information from the at least one sensor assembly at the plurality of times and locations and to transmit the information to at least one information receiving location; and at least one computer at the at least one information receiving location for receiving the information transmitted via the communications network and for providing an information output representing the at least one parameter at the plurality of times.

20 Claims, 12 Drawing Sheets



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U.S. Appl. No. 60/474,692.

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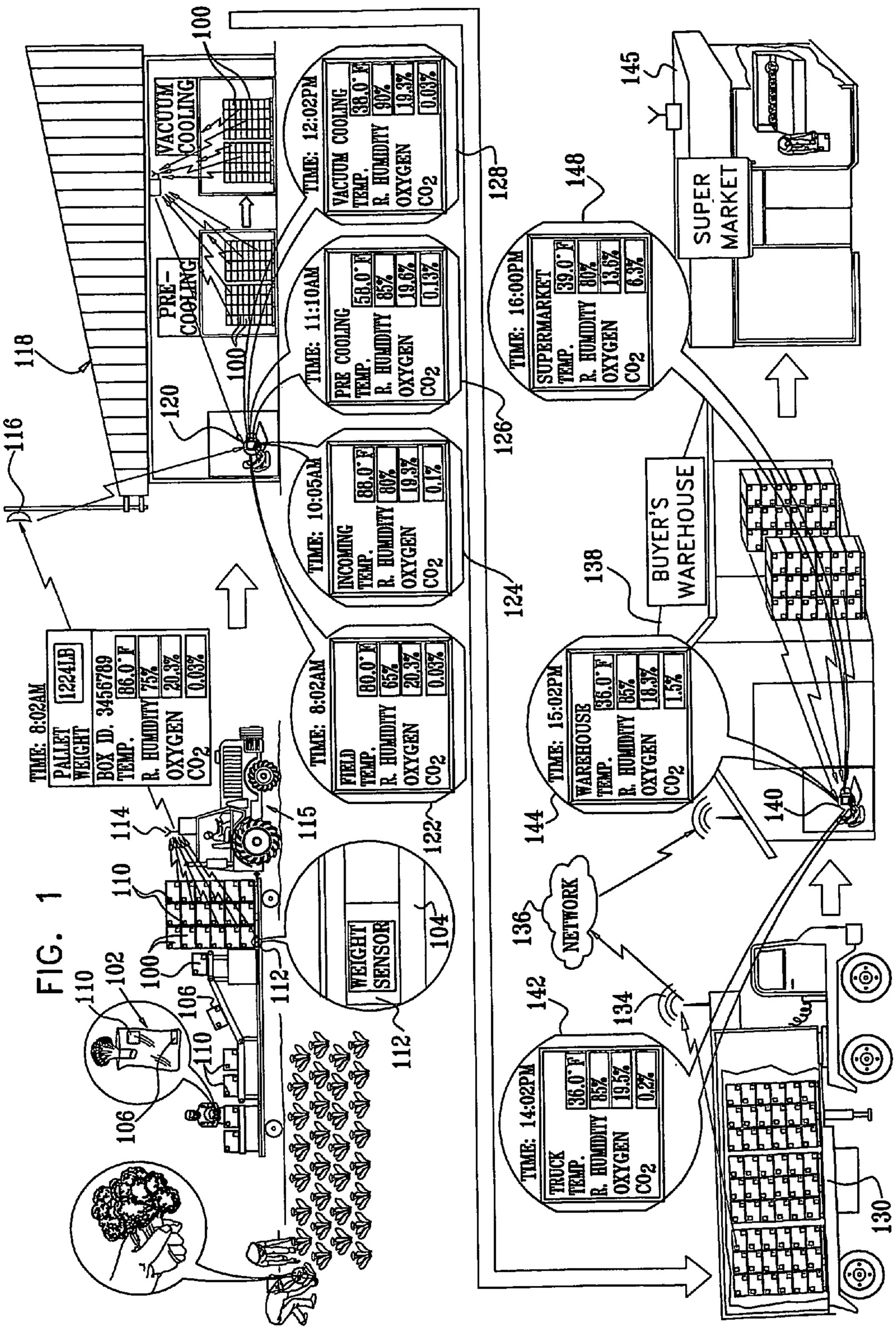
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PALLET WEIGHT 1224LB
BOX ID. 3456789
TEMP. 86.0°F
R. HUMIDITY 75%
OXYGEN 20.3%
CO_2 0.03%
TIME: 8:02AM
FIELD
TEMP. 80.0°F
R. HUMIDITY 65%
OXYGEN 20.3%
CO_2 0.03%
TIME: 10:05AM
INCOMING
TEMP. 88.0°F
R. HUMIDITY 80%
OXYGEN 19.3%
CO_2 0.1%
TIME: 11:10AM
PRE COOLING
TEMP. 58.0°F
R. HUMIDITY 85%
OXYGEN 19.6%
CO_2 0.13%
TIME: 12:02PM
VACUUM COOLING
TEMP. 38.0°F
R. HUMIDITY 90%
OXYGEN 19.3%
CO_2 0.03%
TIME: 16:00PM
SUPERMARKET
TEMP. 39.0°F
R. HUMIDITY 80%
OXYGEN 13.6%
CO_2 6.3%
TIME: 15:02PM
WAREHOUSE
TEMP. 36.0°F
R. HUMIDITY 85%
OXYGEN 18.3%
CO_2 1.5%
TIME: 14:02PM
TRUCK
TEMP. 36.0°F
R. HUMIDITY 85%
OXYGEN 19.5%
CO_2 0.2%
WEIGHT SENSOR
VACUUM COOLING
PRE-COOLING
SUPER MARKET
BUYER'S WAREHOUSE
NETWORK
100
102
104
106
110
112
114
115
116
118
120
122
124
126
128
130
134
136
138
140
142
144
145
148

FIG. 1

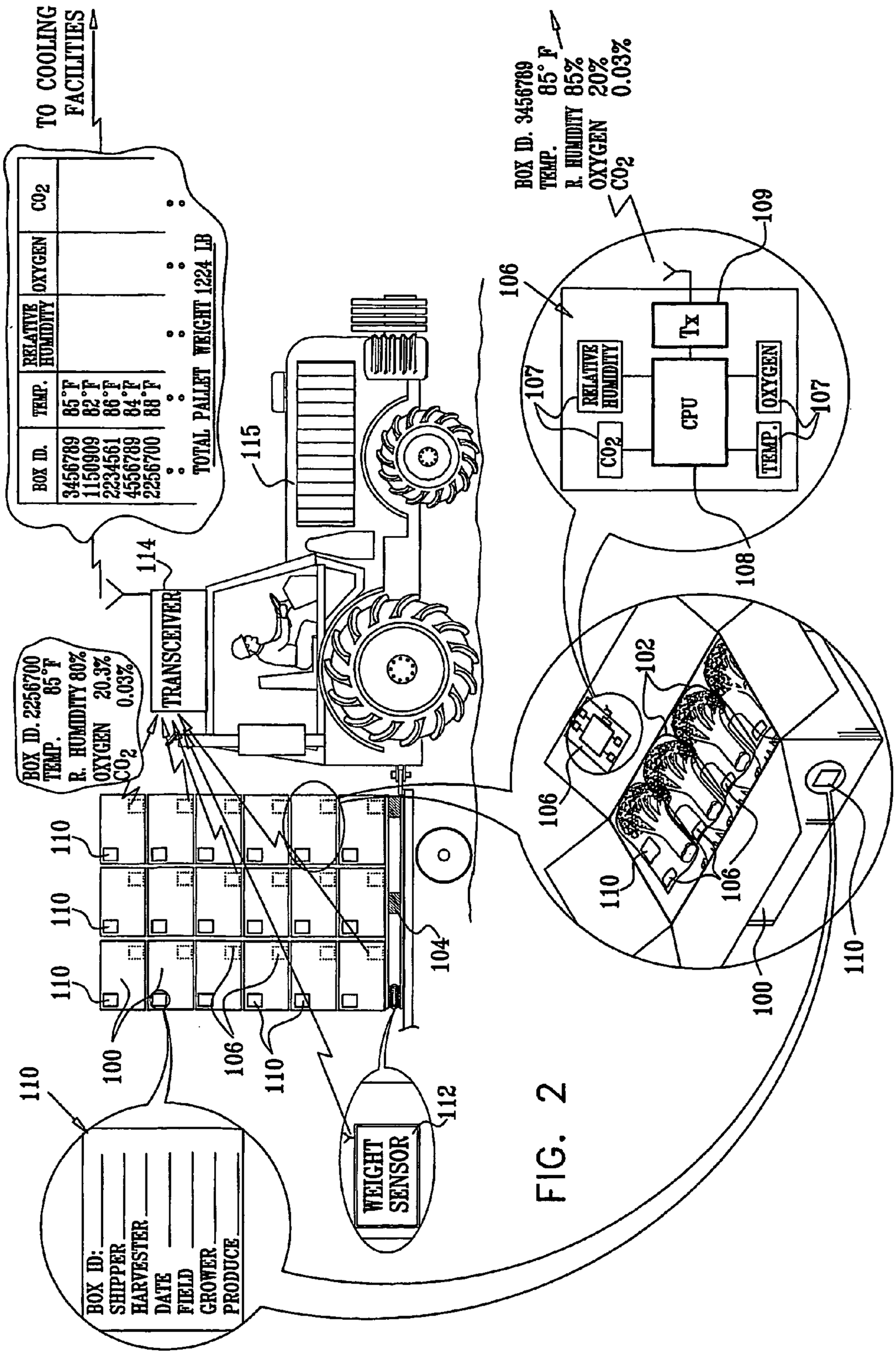
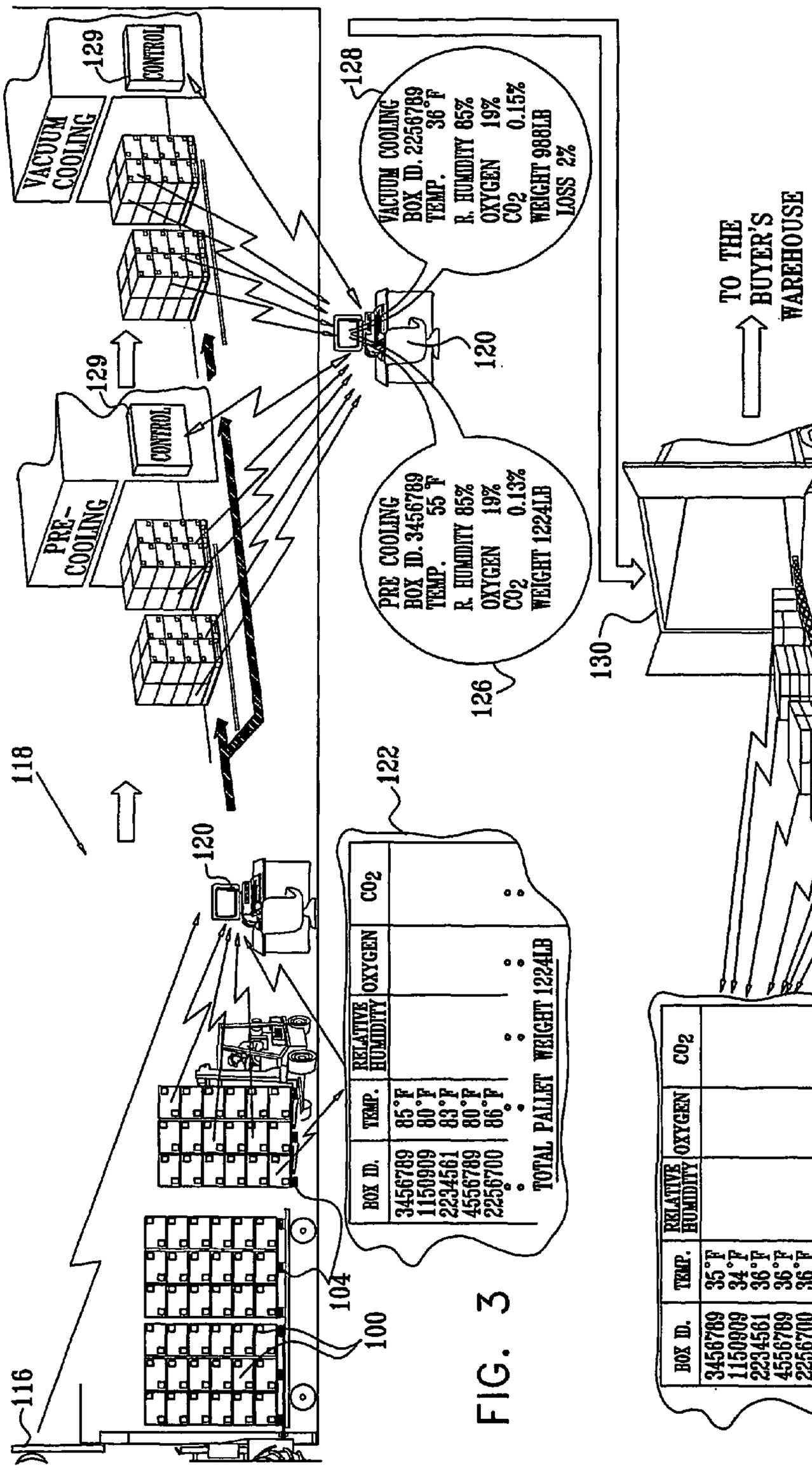

TO COOLING FACILITIES
BOX ID. 3456789
TEMP. 85° F
R. HUMIDITY 85%
OXYGEN 20%
CO_2 0.03%
109
106
107
RELATIVE HUMIDITY
CO_2
CPU
Tx
OXYGEN
TEMP.
108
BOX ID. 2256700
TEMP. 85°F
R. HUMIDITY 80%
OXYGEN 20.3%
CO_2 0.03%
TRANSCEIVER
114
115
BOX ID. | TEMP. | RELATIVE HUMIDITY | OXYGEN
3456789 | 85°F
1150909 | 82°F
2234561 | 86°F
4556789 | 84°F
2256700 | 88°F
TOTAL PALLET WEIGHT 1224 LB
110
100
102
104
112
WEIGHT SENSOR
BOX ID:
SHIPPER
HARVESTER
DATE
FIELD
GROWER
PRODUCE

FIG. 2



BOX ID.	TEMP.	RELATIVE HUMIDITY	OXYGEN	CO_2
3456789	85°F			
1150909	80°F			
2234561	83°F			
4556789	80°F			
2256700	86°F			
•	•	•	•	•

TOTAL PALLET WEIGHT 1224LB

BOX ID.	TEMP.	RELATIVE HUMIDITY	OXYGEN	CO_2
3456789	35°F			
1150909	34°F			
2234561	36°F			
4556789	36°F			
2256700	36°F			
•	•	•	•	•

TOTAL PALLET WEIGHT 988LB

FIG. 3

FIG. 4

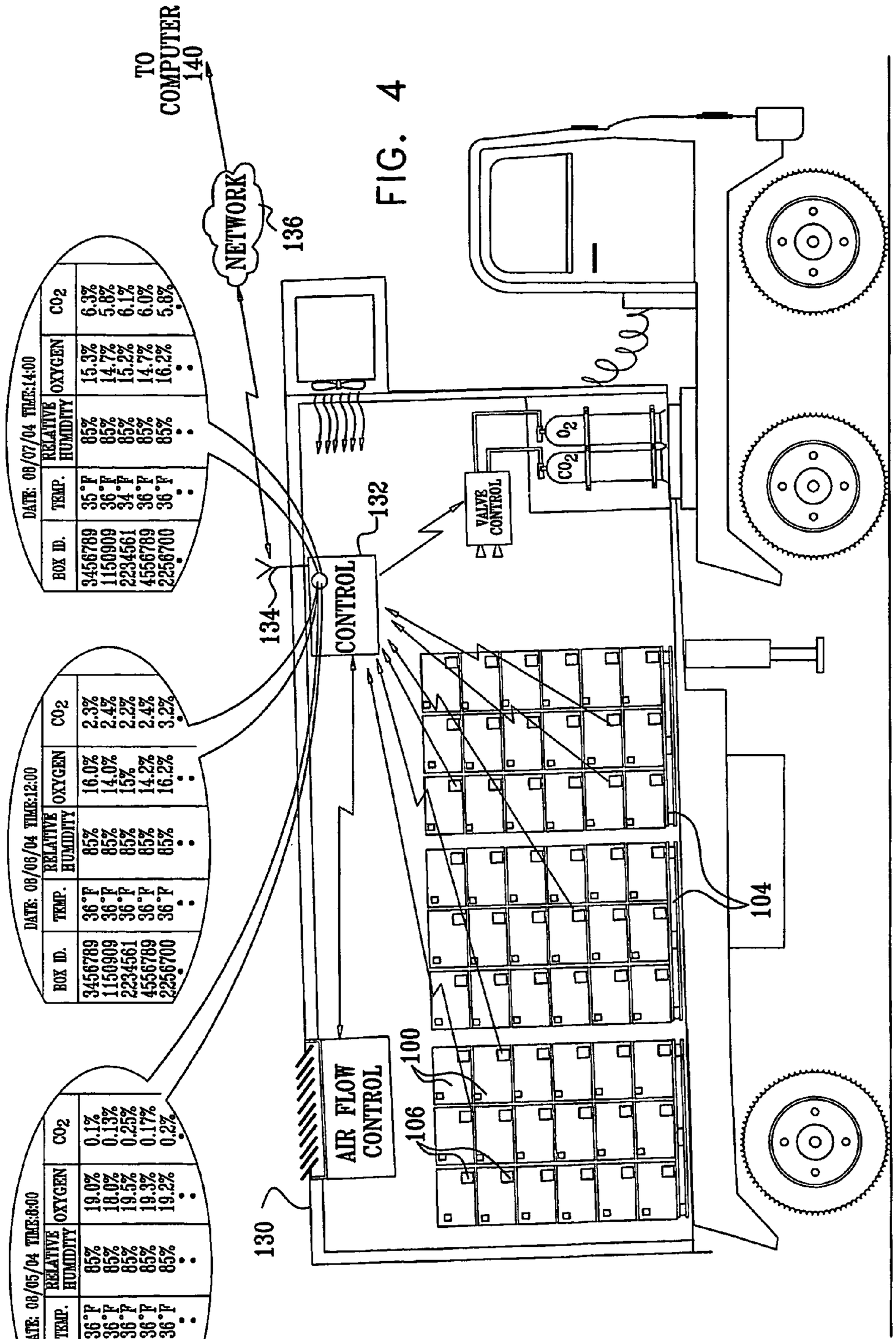
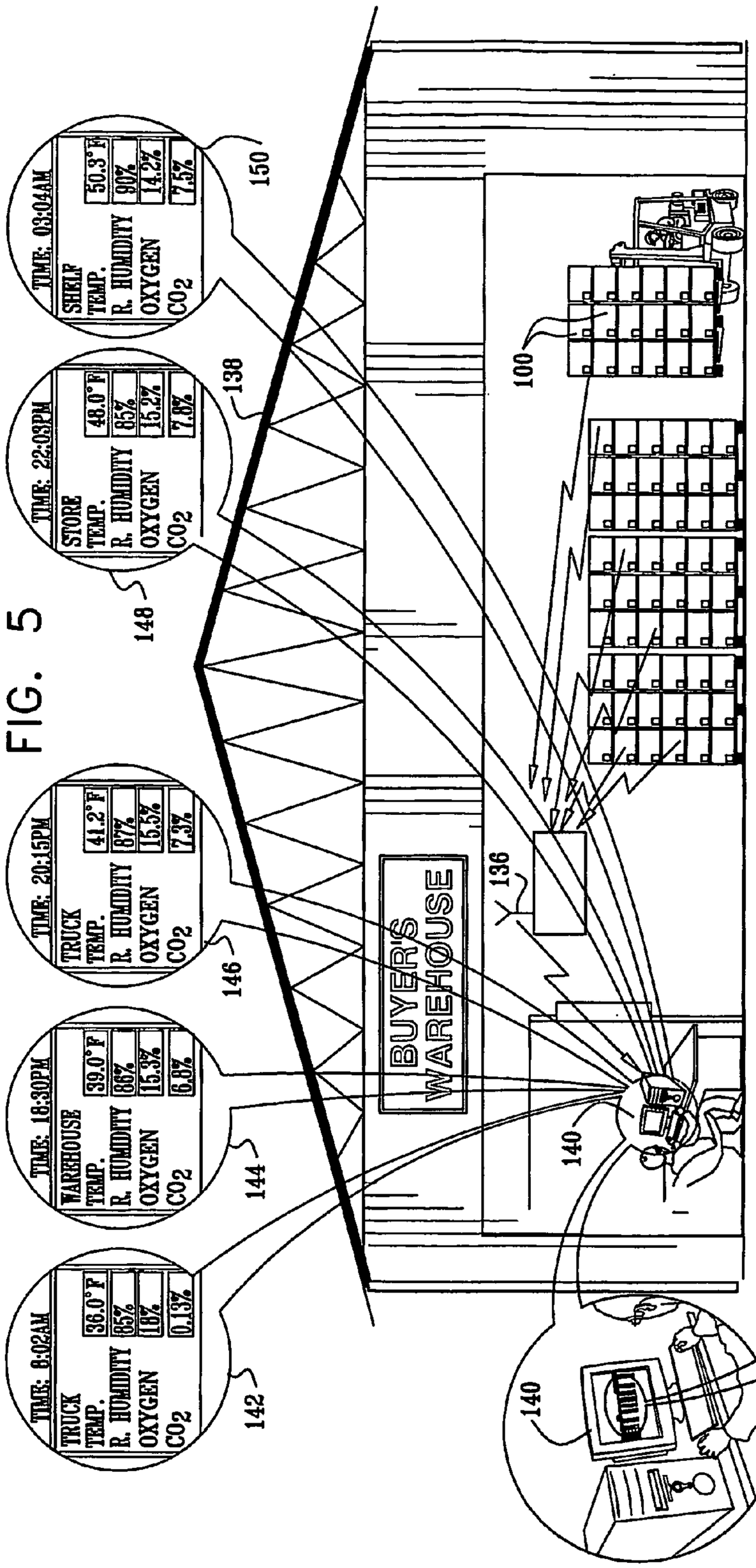

TO COMPUTER 140
NETWORK
136
DATE: 08/07/04 TIME:14:00
BOX ID. | TEMP. | RELATIVE HUMIDITY | OXYGEN | CO_2
3456789 | 35°F | 85% | 15.3% | 6.3%
1150909 | 36°F | 85% | 14.7% | 5.8%
2234561 | 34°F | 85% | 15.2% | 6.1%
4556789 | 36°F | 85% | 14.7% | 6.0%
2256700 | 36°F | 85% | 16.2% | 5.8%
DATE: 08/06/04 TIME:12:00
BOX ID. | TEMP. | RELATIVE HUMIDITY | OXYGEN | CO_2
3456789 | 36°F | 85% | 16.0% | 2.3%
1150909 | 36°F | 85% | 14.0% | 2.4%
2234561 | 36°F | 85% | 15% | 2.2%
4556789 | 36°F | 85% | 14.2% | 2.4%
2256700 | 36°F | 85% | 16.2% | 3.2%
DATE: 08/05/04 TIME:8:00
BOX ID. | TEMP. | RELATIVE HUMIDITY | OXYGEN | CO_2
3456789 | 36°F | 85% | 19.0% | 0.1%
1150909 | 36°F | 85% | 18.0% | 0.13%
2234561 | 36°F | 85% | 19.5% | 0.25%
4556789 | 36°F | 85% | 19.3% | 0.17%
2256700 | 36°F | 85% | 19.2% | 0.2%
CONTROL
132
134
VALVE CONTROL
O_2
CO_2
104
100
106
AIR FLOW CONTROL
130

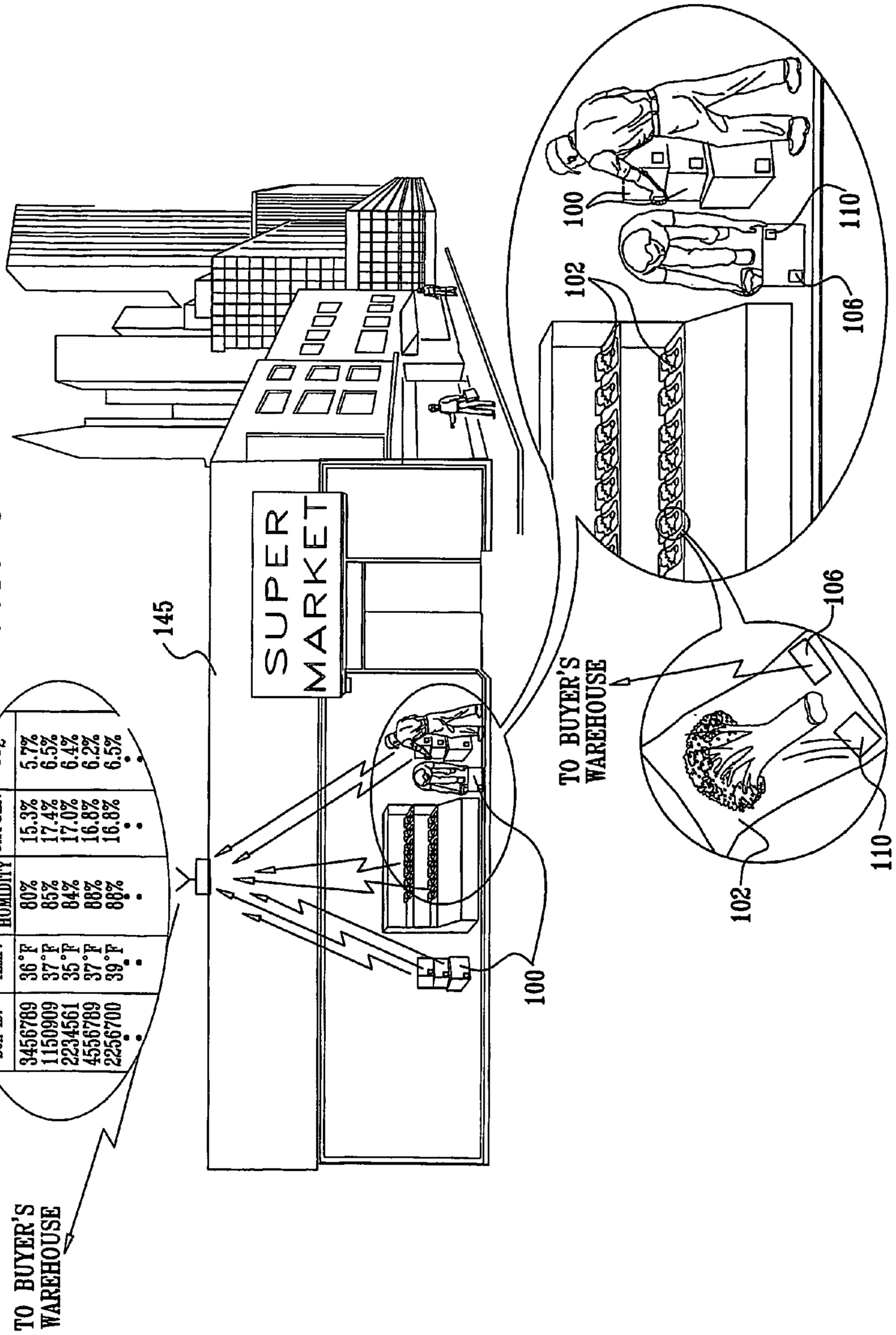
FIG. 5



COOLING FACILITIES						TRUCK					
WEIGHT	TEMP.	R. HUMIDITY	OXYGEN	CO2	WEIGHT	TEMP.	R. HUMIDITY	OXYGEN	CO2	WEIGHT
22LB	38°F	85%	20.3%	0.1%	22LB	34°F	80%	20.3%	0.03%	22LB
22.5LB	36°F	80%	19.0%	0.2%	22.5LB	34°F	75%	20.0%	0.04%	22.5LB
22.5LB	34°F	76%	19.6%	0.15%	22.5LB	33°F	80%	20.1%	0.06%	22.5LB
22.5LB	36°F	80%	19.4%	0.17%	22.5LB	33°F	78%	20.3%	0.2%	22.5LB
22.5LB	32°F	76%	20.0%	0.2%	22.5LB	34°F	81%	20.4%	0.1%	22.5LB
•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•

FIELD					
BOX ID.	TEMP.	R. HUMIDITY	OXYGEN	CO2	WEIGHT
3456789	85°F	80%	20.3%	0.03%	22LB
1150909	85°F	75%	20.0%	0.04%	22.5LB
2234561	85°F	80%	20.1%	0.06%	22.5LB
4556789	85°F	78%	20.3%	0.2%	22.5LB
2256700	85°F	81%	20.4%	0.1%	22.5LB
•	•	•	•	•	•
•	•	•	•	•	•

FIG. 6


SUPER MARKET
145
100
102
106
110
TO BUYER'S WAREHOUSE
BOX ID.
TEMP.
RELATIVE HUMIDITY
OXYGEN
CO_2
3456789 36°F 80% 15.3% 5.7%
1150909 37°F 85% 17.4% 6.5%
2234561 35°F 84% 17.0% 6.4%
4556789 37°F 88% 16.8% 6.2%
2256700 39°F 88% 16.8% 6.5%

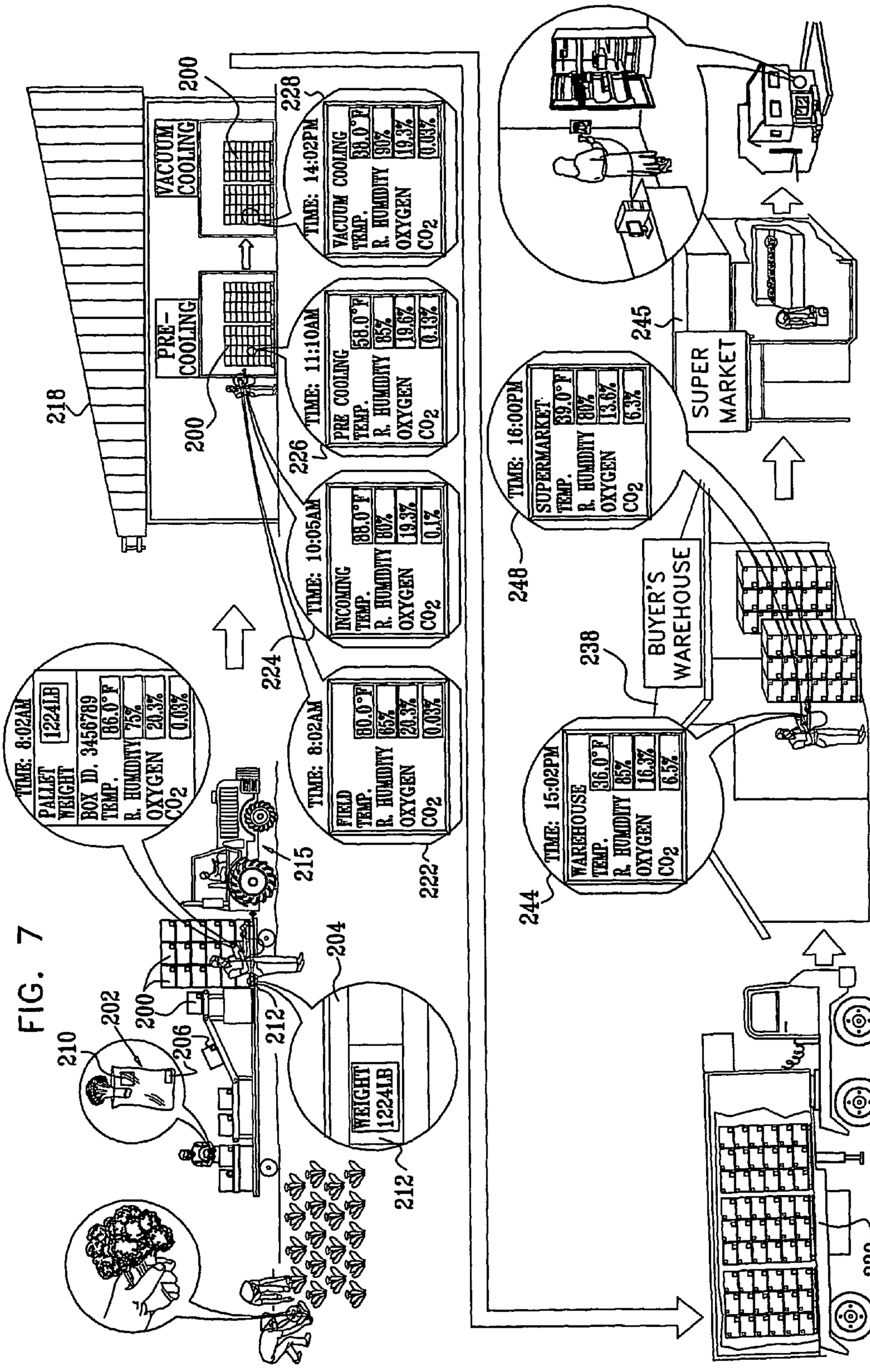

200
228
VACUUM COOLING
TIME: 14:02PM
VACUUM COOLING
TEMP. 88.0°F
R. HUMIDITY 90%
OXYGEN 19.3%
CO_2 0.03%
218
PRE-COOLING
200
226
TIME: 11:10AM
PRE COOLING
TEMP. 58.0°F
R. HUMIDITY 85%
OXYGEN 19.6%
CO_2 0.13%
TIME: 10:05AM
INCOMING
TEMP. 88.0°F
R. HUMIDITY 80%
OXYGEN 19.3%
CO_2 0.1%
224
TIME: 8:02AM
FIELD
TEMP. 80.0°F
R. HUMIDITY 65%
OXYGEN 20.3%
CO_2 0.03%
222
TIME: 8:02AM
PALLET WEIGHT 1224LB
BOX ID. 3456789
TEMP. 86.0°F
R. HUMIDITY 75%
OXYGEN 20.3%
CO_2 0.03%
215
204
202
200
206
210
212
WEIGHT
1224LB
212
245
SUPER MARKET
TIME: 16:00PM
SUPERMARKET
TEMP. 89.0°F
R. HUMIDITY 80%
OXYGEN 13.6%
CO_2 6.3%
248
238
BUYER'S WAREHOUSE
TIME: 15:02PM
WAREHOUSE
TEMP. 36.0°F
R. HUMIDITY 85%
OXYGEN 16.3%
CO_2 6.5%
244
230

FIG. 7

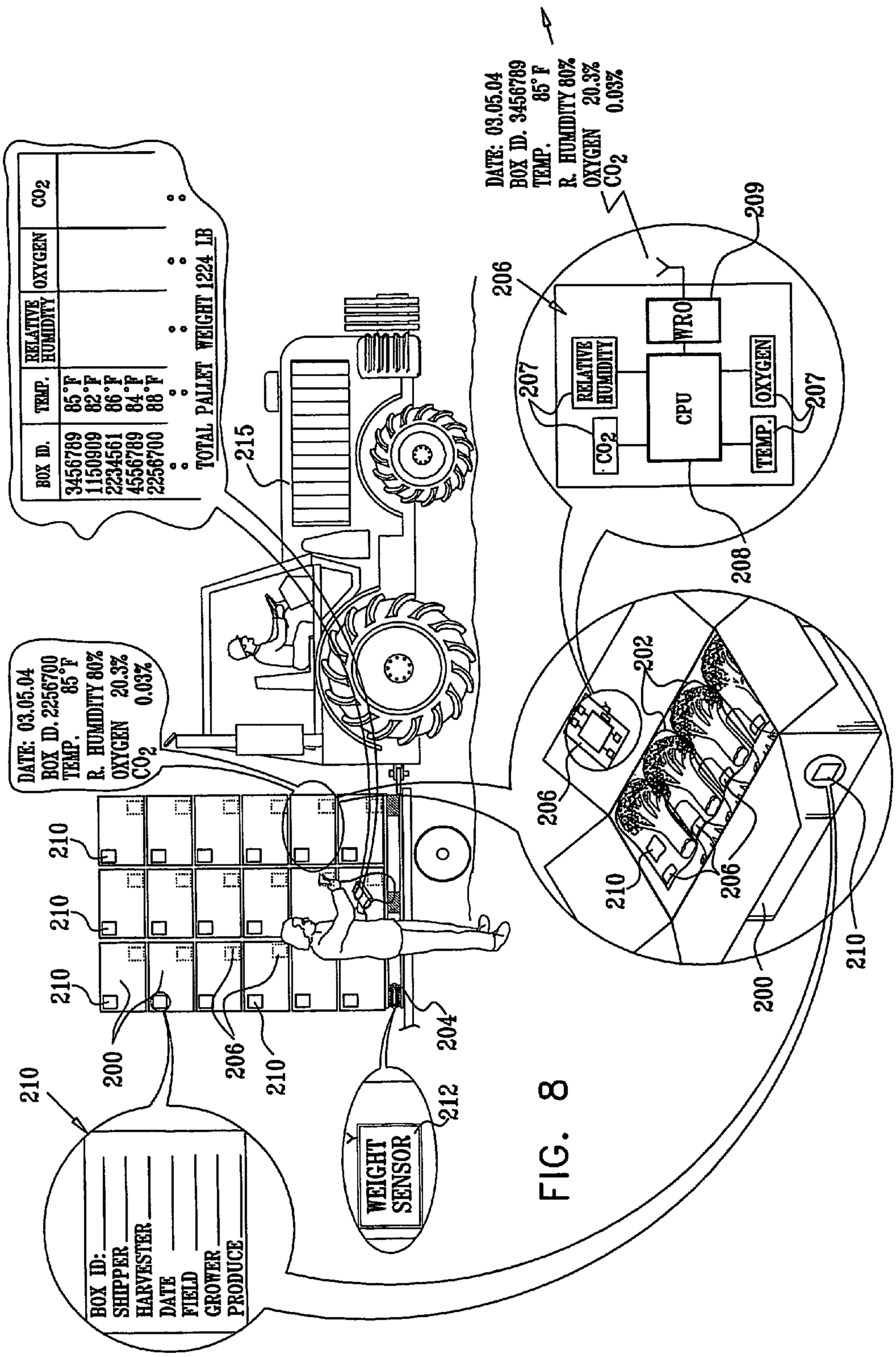

DATE: 03.05.04
BOX ID. 3456789
TEMP. 85°F
R. HUMIDITY 80%
OXYGEN 20.3%
CO_2 0.03%
209
206
RELATIVE HUMIDITY
CO_2
CPU
WRO
OXYGEN
TEMP.
207
208
BOX ID. | TEMP. | RELATIVE HUMIDITY | OXYGEN
3456789 | 85°F
1150909 | 82°F
2234561 | 86°F
4556789 | 84°F
2256700 | 88°F
TOTAL PALLET WEIGHT 1224 LB
215
DATE: 03.05.04
BOX ID. 2256700
TEMP. 85°F
R. HUMIDITY 80%
OXYGEN 20.3%
CO_2 0.03%
202
210
200
204
212
WEIGHT SENSOR
BOX ID:
SHIPPER
HARVESTER
DATE
FIELD
GROWER
PRODUCE

FIG. 8

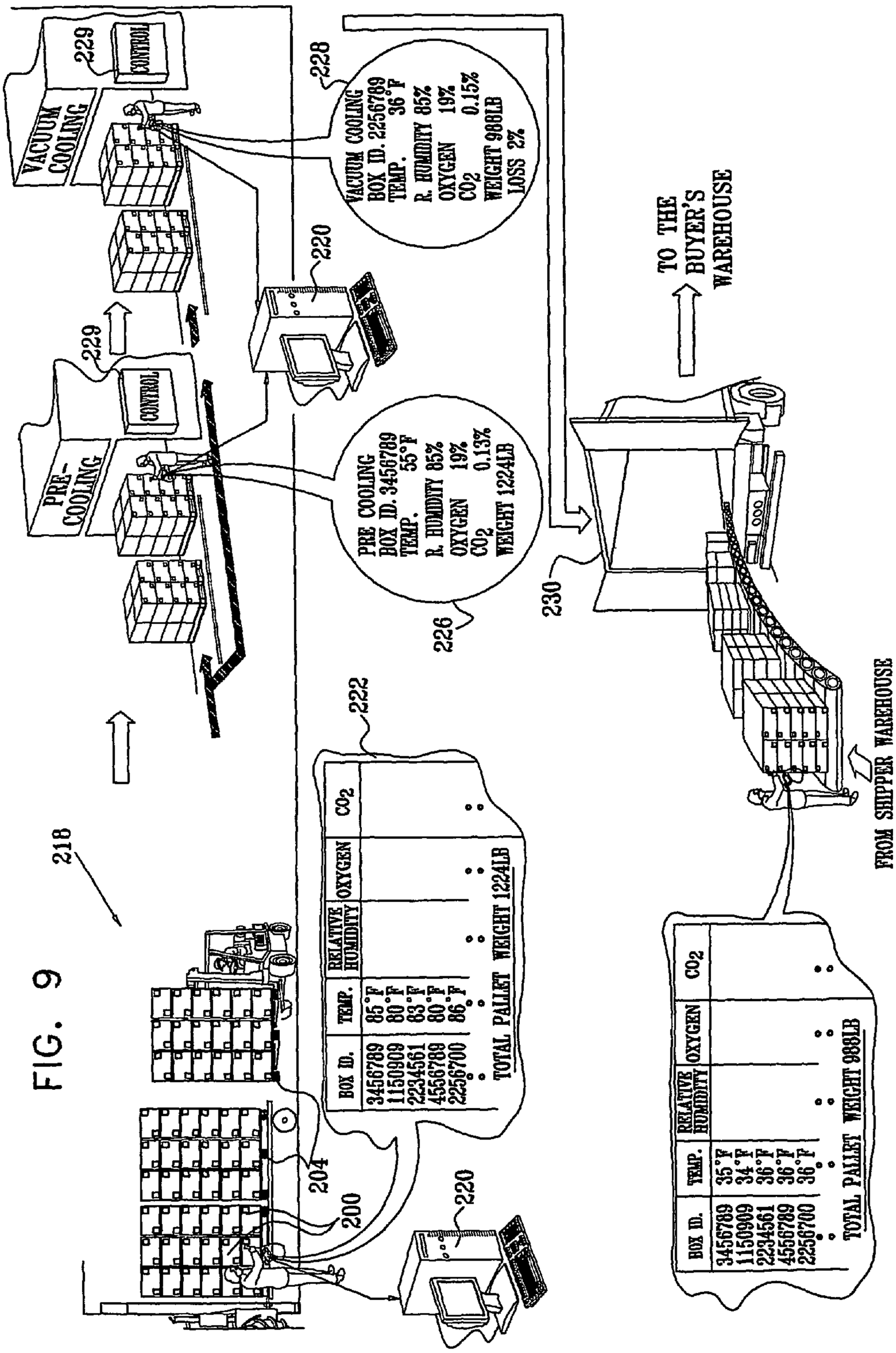

229
CONTROL
VACUUM COOLING
228
VACUUM COOLING
BOX ID. 2256789
TEMP. 36°F
R. HUMIDITY 85%
OXYGEN 19%
CO_2 0.15%
WEIGHT 988LB
LOSS 2%
220
229
CONTROL
PRE-COOLING
PRE COOLING
BOX ID. 3456789
TEMP. 55°F
R. HUMIDITY 85%
OXYGEN 19%
CO_2 0.13%
WEIGHT 1224LB
226
TO THE BUYER'S WAREHOUSE
230
FROM SHIPPER WAREHOUSE
218
222
BOX ID. | TEMP. | RELATIVE HUMIDITY | OXYGEN | CO_2
3456789 | 85°F
1150909 | 80°F
2234561 | 83°F
4556789 | 80°F
2256700 | 86°F
TOTAL PALLET WEIGHT 1224LB
204
200
220
BOX ID. | TEMP. | RELATIVE HUMIDITY | OXYGEN | CO_2
3456789 | 35°F
1150909 | 34°F
2234561 | 36°F
4556789 | 36°F
2256700 | 36°F
TOTAL PALLET WEIGHT 988LB

FIG. 9

FIG. 10

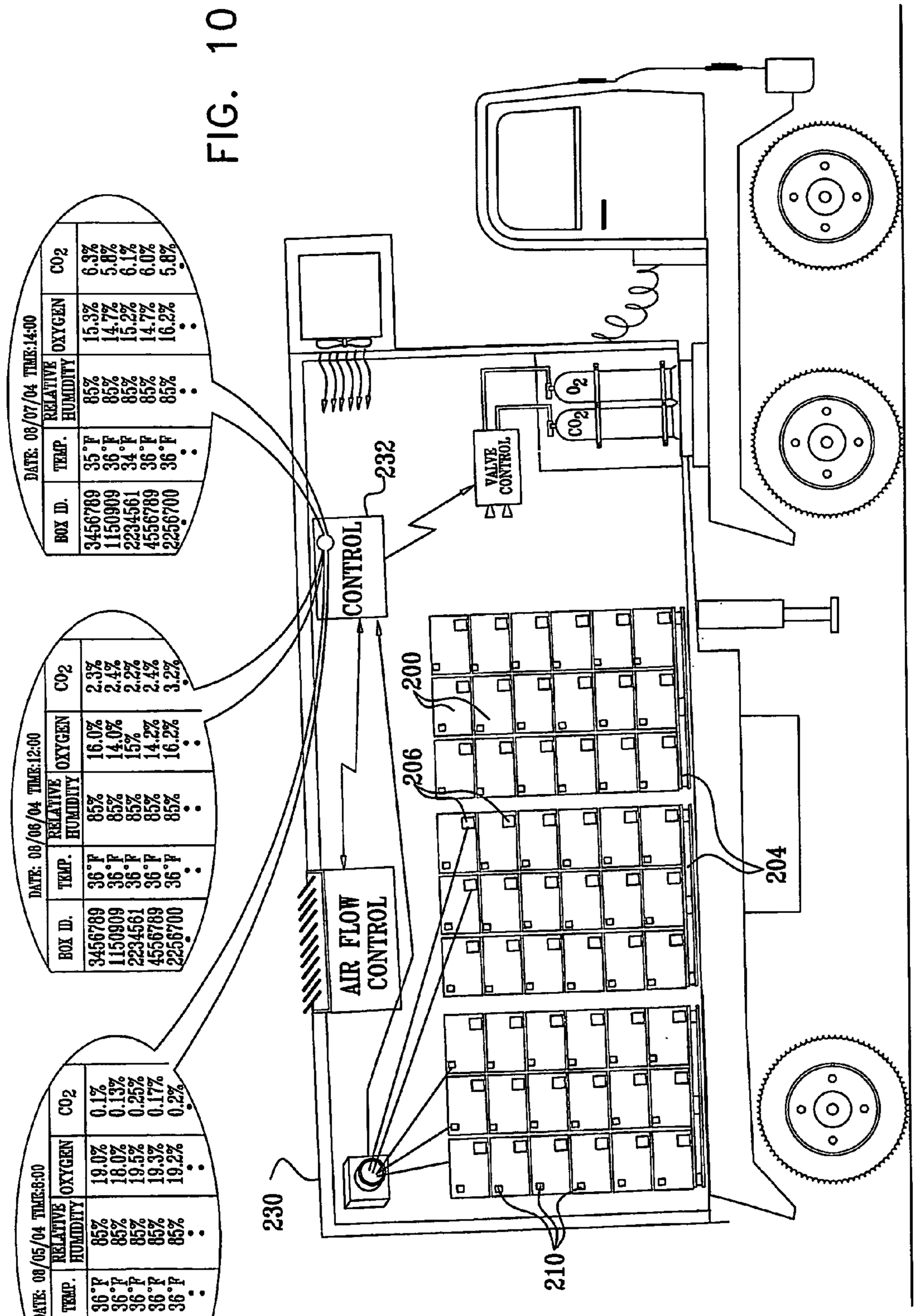
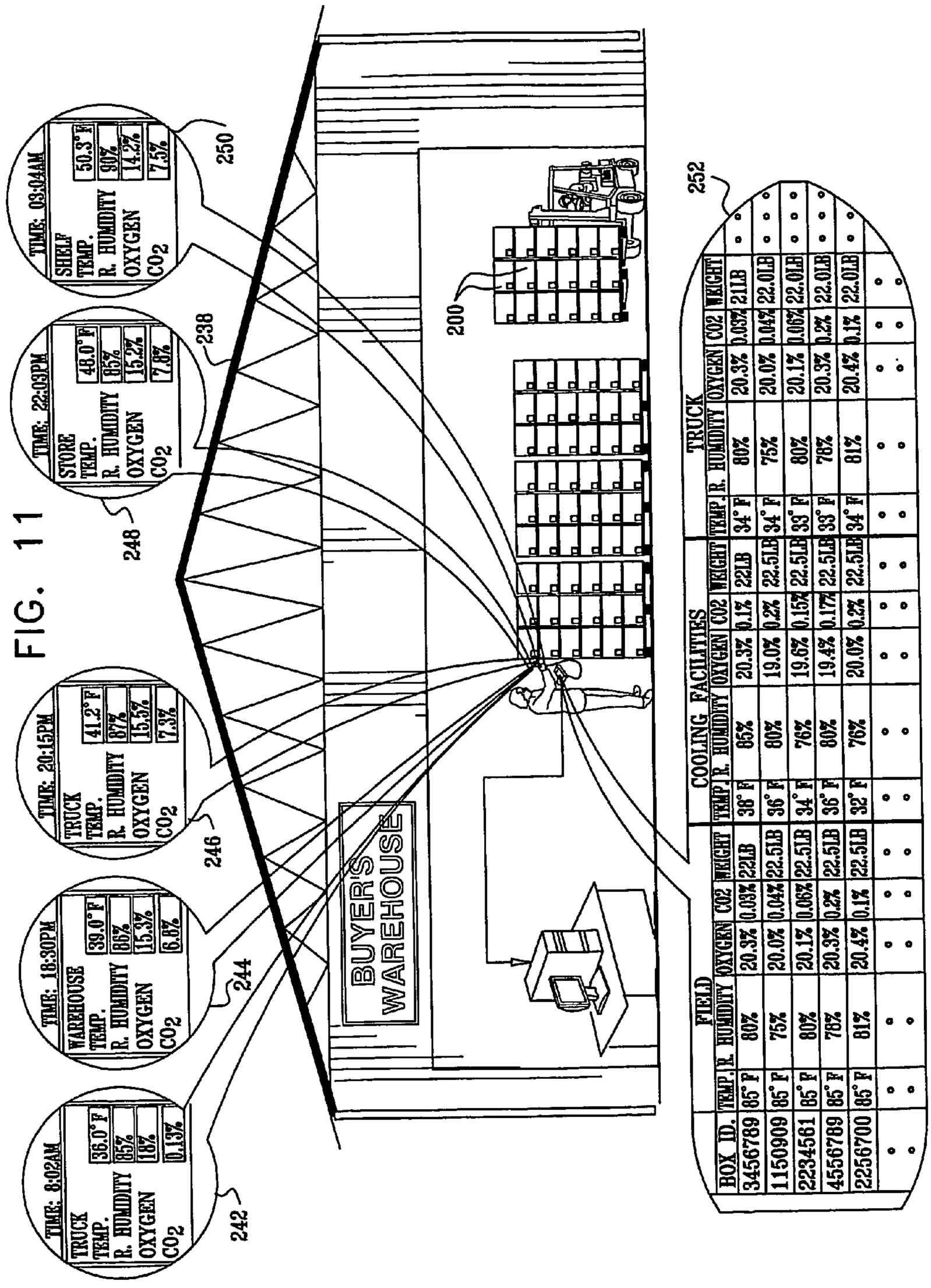

DATE: 08/07/04 TIME:14:00
BOX ID. | TEMP. | RELATIVE HUMIDITY | OXYGEN | CO_2
3456789 | 35°F | 85% | 15.3% | 6.3%
1150909 | 36°F | 85% | 14.7% | 5.8%
2234561 | 34°F | 85% | 15.2% | 6.1%
4556789 | 36°F | 85% | 14.7% | 6.0%
2256700 | 36°F | 85% | 16.2% | 5.8%
DATE: 08/06/04 TIME:12:00
BOX ID. | TEMP. | RELATIVE HUMIDITY | OXYGEN | CO_2
3456789 | 36°F | 85% | 16.0% | 2.3%
1150909 | 36°F | 85% | 14.0% | 2.4%
2234561 | 36°F | 85% | 15% | 2.2%
4556789 | 36°F | 85% | 14.2% | 2.4%
2256700 | 36°F | 85% | 16.2% | 3.2%
DATE: 08/05/04 TIME:8:00
BOX ID. | TEMP. | RELATIVE HUMIDITY | OXYGEN | CO_2
3456789 | 36°F | 85% | 19.0% | 0.1%
1150909 | 36°F | 85% | 18.0% | 0.13%
2234561 | 36°F | 85% | 19.5% | 0.25%
4556789 | 36°F | 85% | 19.3% | 0.17%
2256700 | 36°F | 85% | 19.2% | 0.2%
CONTROL
232
VALVE CONTROL
O_2
CO_2
AIR FLOW CONTROL
200
206
204
230
210

FIG. 11

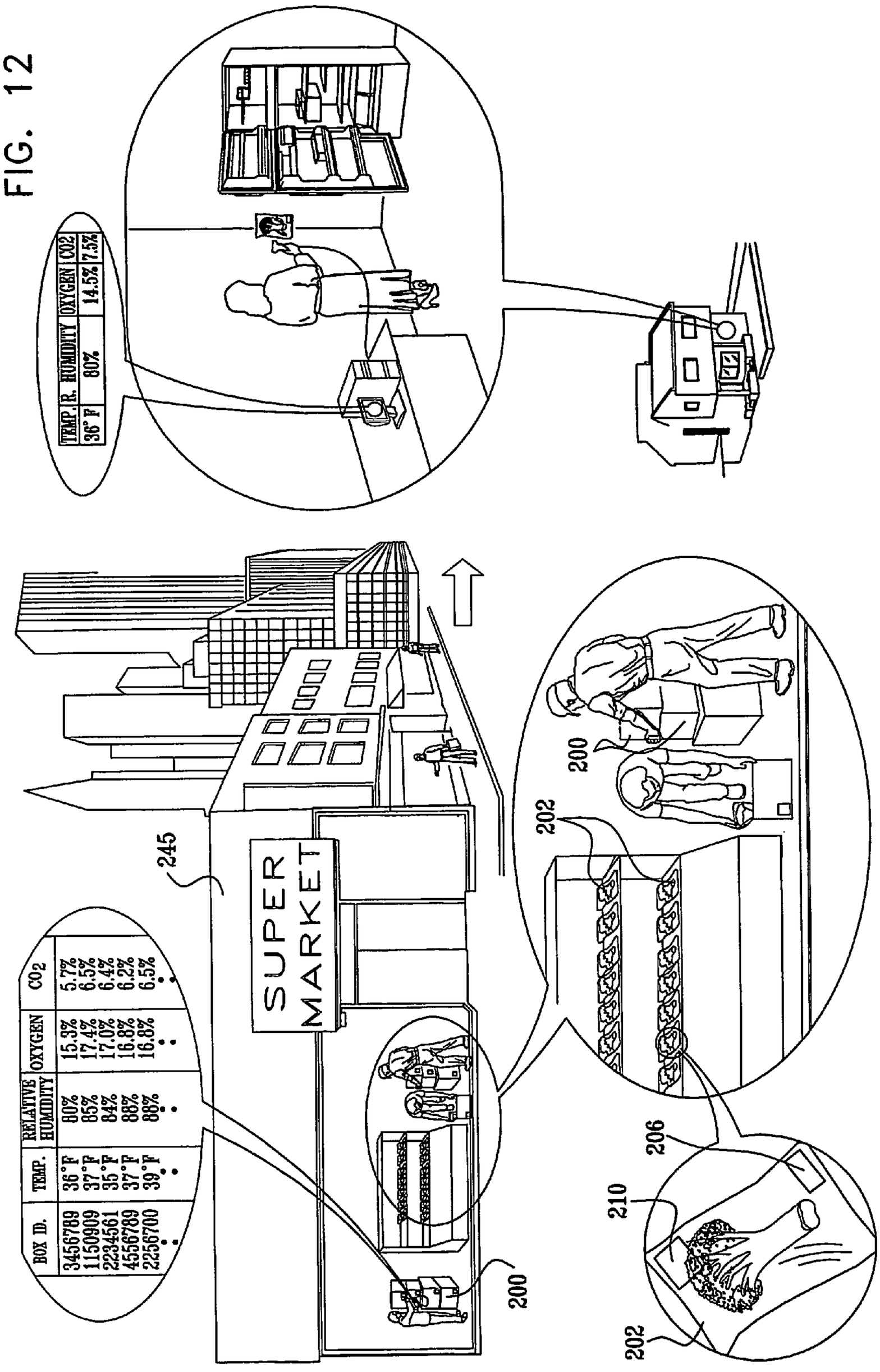


BOX ID.	TEMP.	R. HUMIDITY	OXYGEN	CO2	WEIGHT
3456789	36°F	85%	20.3%	0.1%	22LB
1150909	36°F	80%	19.0%	0.2%	22.51LB
2234561	34°F	76%	19.6%	0.15%	22.51LB
4556789	36°F	80%	19.4%	0.17%	22.51LB
2256700	32°F	76%	20.0%	0.2%	22.51LB
...	...	...	...	...	...

BOX ID.	TEMP.	R. HUMIDITY	OXYGEN	CO2	WEIGHT
3456789	34°F	80%	20.3%	0.03%	21LB
1150909	34°F	75%	20.0%	0.04%	22.0LB
2234561	33°F	80%	20.1%	0.06%	22.0LB
4556789	33°F	78%	20.3%	0.2%	22.0LB
2256700	34°F	81%	20.4%	0.1%	22.0LB
...	...	...	...	...	...

BOX ID.	TEMP.	R. HUMIDITY	OXYGEN	CO2
3456789	85°F	80%	20.3%	0.03%
1150909	85°F	75%	20.0%	0.04%
2234561	85°F	80%	20.1%	0.06%
4556789	85°F	78%	20.3%	0.2%
2256700	85°F	81%	20.4%	0.1%
...	...	...	...	...

FIG. 12


TEMP. R. HUMIDITY OXYGEN CO2
36°F 80% 14.5% 7.5%
245
SUPER MARKET
200
202
206
210
BOX ID. TEMP. RELATIVE HUMIDITY OXYGEN CO_2
3456789 36°F 80% 15.3% 5.7%
1150909 37°F 85% 17.4% 6.5%
2234561 35°F 84% 17.0% 6.4%
4556789 37°F 88% 16.8% 6.2%
2256700 39°F 88% 16.8% 6.5%

PRE AND POST-HARVEST QC DATA ACQUISITION SYSTEM FOR AGRICULTURAL PRODUCTS

REFERENCE TO RELATED APPLICATIONS

The present application is a continuation-in-part of and claims priority from U.S. Patent Application Ser. No. 60/474,692, filed May 29, 2003, entitled VACUUM COOLING SYSTEM AND METHOD, the disclosure of which is hereby incorporated by reference.

FIELD OF THE INVENTION

The present invention relates to post-harvest handling and treatment of agricultural produce generally and more particularly to cooling and shipping of agricultural produce.

BACKGROUND OF THE INVENTION

The following U.S. patents are believed to represent the current state of the art: U.S. Pat. Nos. 5,333,394, 6,092,430, 6,615,908, 5,872,721, 6,190,710 and 6,740,346.

SUMMARY OF THE INVENTION

The present invention seeks to provide a system and methodology for monitoring, controlling and reporting the condition of agricultural produce during post-harvest handling.

There is thus provided in accordance with a preferred embodiment of the present invention a system for monitoring parameters of produce including:

at least one sensor assembly for sensing at least one parameter of packaged produce at a plurality of times and locations of the packaged produce;

a communications network operative to receive information from the at least one sensor assembly at the plurality of times and locations and to transmit the information to at least one information receiving location; and

at least one computer at the at least one information receiving location for receiving the information transmitted via the communications network and for providing an information output representing the at least one parameter at the plurality of times.

There is also provided in accordance with a preferred embodiment of the present invention a system for monitoring parameters of produce including:

at least one sensor assembly for sensing at least one parameter of packaged produce at a plurality of times and locations of the packaged produce;

a memory operative to store information received from the at least one sensor assembly at the plurality of times and locations and to read out the information at least one information receiving location; and

at least one computer at the at least one information receiving location for receiving the information received from the memory and for providing an information output representing the at least one parameter at the plurality of times.

There is additionally provided in accordance with a preferred embodiment of the present invention a method for monitoring parameters of produce including:

sensing at least one parameter of packaged produce at a plurality of times and locations of the packaged produce;

receiving information from said at least one sensor assembly at said plurality of times and locations and transmitting said information to at least one information receiving location; and

employing at least one computer at said at least one information receiving location for receiving the information for providing an information output representing the at least one parameter at the plurality of times.

There is further provided in accordance with a preferred embodiment of the present invention a method for monitoring parameters of produce including:

sensing at least one parameter of packaged produce at a plurality of times and locations of the packaged produce;

storing information received from the at least one sensor assembly at the plurality of times and locations and reading out the information at least one information receiving location; and

employing at least one computer at the at least one information receiving location for receiving the information received from the memory and for providing an information output representing the at least one parameter at the plurality of times.

Preferably the communications network is operative to receive and transmit the information in at least near real time to the at least one information receiving location.

In accordance with a preferred embodiment of the present invention the system and method employ at least one parameter controller operative in response to at part of the information received via the communications network for controlling at least one of the at least one parameter at at least one time and location.

Preferably, at least one sensor assembly is located within a carton containing multiple items of produce.

Alternatively, the at least one sensor assembly is located within a retail sales package.

As a further alternative, the at least one sensor assembly is associated with multiple packages of produce palletized together.

In accordance with a preferred embodiment of the present invention, the at least one sensor assembly includes functionality for sensing at least one of: temperature, oxygen concentration, CO2 concentration, ethylene concentration and relative humidity.

Preferably, the at least one sensor assembly includes functionality for sensing at least two of: temperature, oxygen concentration, CO2 concentration, ethylene concentration and relative humidity.

More preferably, the at least one sensor assembly includes functionality for sensing at least three of: temperature, oxygen concentration, CO2 concentration, ethylene concentration and relative humidity.

In accordance with a preferred embodiment of the present invention, the at least one parameter controller includes a vacuum cooling controller and the system and method is operative to govern vacuum cooling operation based at least on sensed weight loss of the produce. Preferably, the at least one parameter controller includes a cooling controller and wherein the system is operative to govern cooling operation based at least on sensed temperature.

In accordance with a preferred embodiment of the present invention, the at least one parameter controller includes at least one of a humidity controller, a temperature controller and a gas concentration controller and the system and the method are operative to govern at least one of humidity, temperature and gas concentration based on at least one of sensed humidity, temperature and gas concentration. Preferably, the gas concentration is a concentration of at least one of oxygen, CO2 and ethylene.

Normally, the produce whose parameters are monitored includes at least one of milk products, fruits and vegetables.

In accordance with a preferred embodiment of the present invention, the at least one sensor assembly senses at least one parameter of packaged produce at locations of the packaged produce including at least one and more preferably at least two of a produce harvesting location, a produce cooling location, a produce transporting location, a buyer's warehouse and a retail location.

Preferably, the at least one sensor assembly is located within a modified-atmosphere enclosure enclosing the produce. Alternatively, the at least one sensor assembly is located outside a modified-atmosphere enclosure enclosing the produce.

In accordance with a preferred embodiment of the invention, the memory and/or the communications network is also operative to receive information including at least one of packaging unit ID; shipper ID, harvester ID, grower ID, field ID and produce type ID.

Preferably the system and method employ a produce weight change sensor.

In accordance with a preferred embodiment of the present invention the parameter sensing includes or enables sensing produce parameters by a consumer at a consumer facility.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood and appreciated more fully from the following detailed description, taken in conjunction with the drawings in which:

FIG. **1** is a simplified illustration of a system and methodology for monitoring and controlling parameters of post-harvest handling of agricultural produce in accordance with a preferred embodiment of the present invention;

FIG. **2** is a simplified illustration of a typical field-based portion of the system and methodology of FIG. **1**;

FIG. **3** is a simplified illustration of a typical packing, cooling and shipping facility-based portion of the system and methodology of FIG. **1**;

FIG. **4** is a simplified illustration of a typical transport vehicle-based portion of the system and methodology of FIG. **1**;

FIG. **5** is a simplified illustration of a typical buyer's warehouse-based portion of the system and methodology of FIG. **1**;

FIG. **6** is a simplified illustration of a typical retail facility-based portion of the system and methodology of FIG. **1**;

FIG. **7** is a simplified illustration of a system and methodology for monitoring and controlling parameters of post-harvest handling of agricultural produce in accordance with another preferred embodiment of the present invention;

FIG. **8** is a simplified illustration of a typical field-based portion of the system and methodology of FIG. **7**;

FIG. **9** is a simplified illustration of a typical packing and cooling facility-based portion of the system and methodology of FIG. **7**;

FIG. **10** is a simplified illustration of a typical transport vehicle-based portion of the system and methodology of FIG. **7**;

FIG. **11** is a simplified illustration of a typical buyer's warehouse-based portion of the system and methodology of FIG. **7**; and

FIG. **12** is a simplified illustration of a typical retail facility and consumer facility-based portion of the system and methodology of FIG. **7**.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Reference is now made to FIGS. **1-6**, which are simplified illustrations of a system and methodology for monitoring and controlling parameters of post-harvest handling of agricultural produce in accordance with a preferred embodiment of the present invention.

As seen in FIGS. **1-6**, agricultural produce, such as broccoli, is harvested in a field and packaged in cartons **100**. In accordance with one preferred embodiment of the present invention, one or more items of produce are packaged within a modified-atmosphere enclosure, such as a sealed plastic bag **102**, preferably formed of XTEND® material, commercially available from the present assignee, Stepac L. A. Ltd. of Tefen, Western Galilee, Israel. Preferred modified-atmosphere material useful in such bags is described in assignee's U.S. Pat. No. 6,190,710, the disclosure of which is hereby incorporated by reference. Preferred bag and carton structures are described in assignee's U.S. Pat. No. 6,740,346, the disclosure of which is hereby incorporated by reference. Different types of modified-atmosphere enclosures may be suitable for different types of produce. Some produce need not be packaged in modified-atmosphere enclosures.

One or more sealed plastic bags **102** are placed within each carton **100** and the cartons are closed and then stacked on a pallet **104**. Alternatively, modified-atmosphere enclosures are not employed and the produce is placed directly within each carton or other package.

In accordance with a preferred embodiment of the present invention, each packaging unit is provided with at least one sensor assembly **106** for sensing at least one parameter of packaged produce at a plurality of times and locations of the packaged produce. Alternatively less than all of the packaging units are provided with sensor assemblies **106**, but a sufficient number of sensor assemblies **106** are employed in order to provide a representative sampling of produce parameters. In accordance with a preferred embodiment of the present invention, the packaging unit is the carton **100** and the sensor assembly **106** may be mounted onto a surface of the carton **100**, preferably an interior surface. Alternatively, the packaging unit may be the bag **102** and the sensor assembly **106** may be placed therein. As a further alternative, the packaging unit may be a stack of cartons, such as a palletized stack, or even a truckload of cartons or other packages.

In one embodiment of the invention, bags **102** may be retail sale packages, which are not opened other than by the consumer. In such a case, an individual sensor assembly **106** may be provided for each retail sale package, providing the opportunity for a consumer to receive an indication of at least one parameter of the produce contained in a specified bag throughout its post-harvest handling, possibly including storage at consumer premises.

In another embodiment of the invention, bags **102** and cartons **100** are wholesale unit packages, which are opened at a retail sales facility, such as a supermarket. In such a case, an individual sensor assembly **106** may be provided for such bag **102** or carton **100**, providing the opportunity for a wholesale buyer to receive an indication of at least one parameter of the produce contained in a specified bag **102** or carton **100** throughout its post-harvest handling, even enroute, so as to be able to reject shipments whose parameters do not meet the buyer's requirements, even before delivery. When not all of

the packaging units are equipped with sensor assemblies **106**, the wholesale buyer receives a representative indication of at least one parameter.

Preferably, each sensor assembly **106** includes a plurality of individual parameter sensors **107**, such as a CO2 sensor, a relative humidity sensor, a temperature sensor and an oxygen sensor, which preferably communicate with a CPU **108**, which outputs via a wireless transmitter **109**. The sensor assembly **106** preferably has sleep mode functionality, so as to save power prior to actuation thereof, such as by receipt of a wireless input thereat. Similar actuations may be employed for recording the location of the produce at various times. GPS functionality may also be employed for this purpose and may be incorporated in sensor assemblies **106**.

Preferably, each packaging unit comprises an identifier **110**, typically in the form of a label or tag or alternatively directly printed on a packaging unit, which indicates in a machine and/or human readable form some and preferably all of the following information: packaging unit ID; shipper ID, harvester ID, grower ID, field ID and produce type ID. Preferably, the CPU **108** also includes a downloadable memory, which stores the above identifier information as well as parameters sensed continuously or from time to time by the sensors **107** of the sensor assembly **106**, preferably at least one of temperature, relative humidity, and concentrations of oxygen, CO2 and ethylene and date and time stamps such parameters.

In accordance with a preferred embodiment of the invention, each pallet **104** is equipped with a weight sensor **112**, thereby enabling the weight of the produce supported thereon to be readily monitored. Alternatively, at various relevant stages of post-harvest handling, the pallet may be weighed and changes in the weight recorded and noted.

In accordance with a preferred embodiment of the present invention, wireless transmitter **109** transmits data representing the "static" information appearing on identifier **110**, as well as "dynamic" information representing the variable parameters sensed by sensor assembly **106** and weight sensor **112**. Preferably, the transmitter **109** is operated so as to transmit samples of the above information at spaced time intervals, such as once per hour.

At an initial stage, information transmitted by transmitters **109** may be received by a transceiver **114** mounted onto a tractor **115** or other transport vehicle adjacent to the transmitters **109**. Transceiver **114** may simultaneously or at suitable times transmit this information to a transceiver **116** located at a packing/cooling/shipping facility **118** for receipt by a computer **120** located thereat. It is appreciated that such an arrangement enables a supervisor at the packing/cooling/shipping facility **118** to monitor the condition of produce being harvested, as indicated at reference numeral **122**, and transported to the facility even before the produce arrives, so as to be able to schedule appropriate types and duration of cooling.

Preferably information regarding various relevant parameters of the produce is sampled and stored at computer **120** when the produce arrives at the packing/cooling/shipping facility **118**, as indicated at reference numeral **124**, following pre-cooling, as indicated at reference numeral **126** and following vacuum cooling, as indicated at reference numeral **128**. It is appreciated that, depending on the type of produce and its parameters, various types of cooling or no cooling may be appropriate. Typically the produce parameters sensed at the time of arrival of the produce at facility **118** determine the cooling parameters.

When vacuum cooling is applied, the real-time weight loss of the produce is preferably monitored and used for controlling the extent and duration of vacuum cooling, so as not to dry out the produce to an unacceptable extent. The control functionality may readily be realized by wireless communication between computer **120** and one or more cooling controllers **129**.

Monitoring of the various parameters of the produce by sensor assemblies **106** preferably continues while the produce is stored in cold storage prior to loading and while it is loaded onto transport vehicles **130** for shipment to customers and for the duration of the shipment. Normally, such monitoring enables real-time or manual control of at least one parameter of the produce, normally temperature, by suitable control of a transport vehicle cooling system. When controlled-atmosphere shipping containers, such as those employing Carrier Transicold EverFresh container refrigeration units, commercially available from Carrier Corporation, are employed, the oxygen, CO2, ethylene and relative humidity of the produce may also be controlled in real-time or near real-time by employing an on-board computer **132** for controlling ventilation and release of pressurized gases into the interior of the transport vehicle in response to outputs of the sensor assemblies **106**.

During transport, information transmitted by transmitters **109** may be received by a transceiver **134** mounted onto the transport vehicle **130**. Transceiver **134** may simultaneously or at suitable times transmit this information via a communications network **136**, such as the internet or via a proprietary wireless network such as a cellular network, or via any other suitable communications link to a buyer's warehouse facility **138** for receipt by a computer **140** located thereat. It is appreciated that such an arrangement enables a supervisor at the buyer's warehouse facility **138** to monitor the condition of produce being shipped, as indicated at reference numeral **142**, even before the produce arrives, so as to be able to reject shipments enroute which do not meet the buyer's requirements or to schedule shipments to retail outlets as a function of anticipated shelf life of the produce being shipped.

Preferably, information regarding various relevant parameters of the produce is also sampled and stored at computer **140** when the produce arrives at the buyer's warehouse facility **138**, as indicated at reference numeral **144**, during shipment to a retail outlet **145**, as indicated at reference numeral **146**, when it arrives at the retail outlet **145**, as indicated at reference numeral **148**, and possibly until such time as it is removed from the packaging unit, as indicated at reference numeral **150**. A comprehensive report on the parameter history of the produce, such as indicated at reference numeral **152** is preferably made available to the supervisor. Such a report may be presented for each packaging unit or alternatively may be summarized and/or averaged for groups of packaging units.

Reference is now made to FIGS. **7-12**, which are simplified illustrations of a system and methodology for monitoring and controlling parameters of post-harvest handling of agricultural produce in accordance with another preferred embodiment of the present invention. The embodiment of FIGS. **7-12** differs from that of FIGS. **1-6** in that it typically does not include long-distance wireless transmission functionality, but instead employs only memory functionality that accompanies the produce packaging unit from the field to the consumer.

As seen in FIGS. **7-12**, agricultural produce, such as broccoli, is harvested in a field and packaged in cartons **200**. In accordance with one preferred embodiment of the present invention, one or more items of produce are packaged within a modified-atmosphere enclosure, such as a sealed plastic bag **202**, preferably formed of XTEND® material, commercially available from the present assignee, Stepac L. A. Ltd. of

Tefen, Western Galilee, Israel. Preferred modified-atmosphere material useful in such bags is described in U.S. Pat. No. 6,190,710, the disclosure of which is hereby incorporated by reference. Preferred bag and carton structures are described in assignee's U.S. Pat. No. 6,740,346, the disclosure of which is hereby incorporated by reference. Different types of modified-atmosphere enclosures may be suitable for different types of produce. Some produce need not be packaged in modified-atmosphere enclosures.

One or more sealed plastic bags **202** are placed within each carton **200** and the cartons are closed and then stacked on a pallet **204**. Alternatively, modified-atmosphere enclosures are not employed and the produce is placed directly within each carton or other package.

In accordance with a preferred embodiment of the present invention, each packaging unit is provided with at least one sensor assembly **206** for sensing at least one parameter of packaged produce at a plurality of times and locations of the packaged produce. Alternatively less than all of the packaging units are provided with sensor assemblies **206**, but a sufficient number of sensor assemblies **206** are employed in order to provide a representative sampling of produce parameters. In accordance with a preferred embodiment of the present invention, the packaging unit is the carton **200** and the sensor assembly **206** may be mounted onto a surface of the carton **200**, preferably an interior surface. Alternatively, the packaging unit may be the bag **202** and the sensor assembly **206** may be placed therein. As a further alternative, the packaging unit may be a stack of cartons, such as a palletized stack, or even a truckload of cartons or other packages.

In one embodiment of the invention, bags **202** may be retail sale packages, which are not opened other than by the consumer. In such a case, an individual sensor assembly **206** may be provided for each retail sale package, providing the opportunity for a consumer to receive an indication of at least one parameter of the produce contained in a specified bag throughout its post-harvest handling, possibly including storage at consumer premises.

In another embodiment of the invention, bags **202** and cartons **200** are wholesale unit packages, which are opened at a retail sales facility, such as a supermarket. In such a case, an individual sensor assembly **206** may be provided for such bag **202** or carton **200**, providing the opportunity for a wholesale buyer to receive an indication of at least one parameter of the produce contained in a specified bag **202** or carton **200** throughout its post-harvest handling, even enroute, so as to be able to reject shipments whose parameters do not meet the buyer's requirements, even before delivery. When not all of the packaging units are equipped with sensor assemblies **206**, the wholesale buyer receives a representative indication of at least one parameter.

Preferably, each sensor assembly **206** comprises a plurality of individual parameter sensors **207**, such as a CO2 sensor, a relative humidity sensor, a temperature sensor and an oxygen sensor, which preferably communicate with a CPU **208**, that preferably includes a downloadable memory, and is associated with wireless readout functionality **209**, such as resonant tag functionality. In accordance with a preferred embodiment of the invention, the sensor assembly **206** may readily be incorporated onto a label or smart card which incorporates a suitable integrated circuit. The contents of the memory may thus be read by any suitable conventional smart card reader, non-contact readout device or the like. The sensor assembly **206** preferably has sleep mode functionality, so as to save power prior to actuation thereof, such as by receipt of a wireless input thereat. Similar actuations may be employed for recording the location of the produce at various times. GPS functionality may also be employed for this purpose and may be incorporated in sensor assemblies **206**.

Preferably, each packaging unit also comprises an identifier **210**, typically in the form of a label or tag, or alternatively directly printed on a packaging unit, which indicates in a machine and/or human readable form some and preferably all of the following information: packaging unit ID; shipper ID, harvester ID, grower ID, field ID and produce type ID. Preferably, the memory also stores the above "static" information as well as "dynamic" information representing parameters sensed continuously or from time to time by sensors **207** of the sensor assembly **206**, preferably at least temperature, relative humidity, and concentrations of oxygen, CO2 and ethylene and date and time stamps such parameters.

In accordance with a preferred embodiment of the invention, each pallet **204** is equipped with a weight sensor **212**, thereby enabling the weight of the produce supported thereon to be readily monitored. Alternatively, at various relevant stages of post-harvest handling, the pallet may be weighed and changes in the weight recorded and noted.

In accordance with a preferred embodiment of the present invention, the memory of each sensor assembly **206** which is preferably mounted on a smart card or the like and which stores produce parameter data over time, is readily read by conventional short range interrogation apparatus, such as IR or Bluetooth communicators. The downloadable information includes both static and dynamic information regarding the origin and post-harvest history of the produce in one or more packaging units.

Interrogation of a memory forming part of or associated with each sensor assembly **206** may take place at all relevant post-harvest stages of the produce, including in the field, just after harvest, during transport to the packing/cooling/shipping facility, upon arrival at the packing/cooling/shipping facility, at various stages during cooling and storage thereafter, during loading for shipment, at various times during shipment, upon arrival at a buyer's warehouse, during storage at a buyer's warehouse, during shipment to a retail outlet, upon arrival at the retail outlet, at various times on the shelf and even during storage at a consumer's premises.

It is appreciated that such an arrangement enables a supervisor in the field and/or at the packing/cooling/shipping facility **218** to monitor the condition of produce being harvested, as indicated at reference numeral **222** even before the produce arrives at the packing/cooling/shipping facility, so as to be able to schedule appropriate types and duration of cooling.

Preferably information regarding various relevant parameters of the produce is read from the memory and stored at computer **220** when the produce arrives at the packing/cooling/shipping facility **218**, as indicated at reference numeral **224**, following pre-cooling, as indicated at reference numeral **226**, following vacuum cooling, as indicated at reference numeral **228** and during storage thereafter. It is appreciated that, depending on the type of produce and its parameters, various types of cooling or no cooling may be appropriate. When vacuum cooling is applied, the real-time weight loss of the produce is preferably monitored and used for controlling the extent and duration of vacuum cooling, so as not to dry out the produce to an unacceptable extent. Typically the produce parameters sensed at the time of arrival of the produce at facility **218** determine the cooling parameters.

Monitoring of the various parameters of the produce by sensor assemblies **206** preferably continues when the produce is loaded onto transport vehicles **230** for shipment to customers and for the duration of the shipment. Normally, such monitoring enables real-time or manual control of at least one parameter of the produce, normally temperature, by suitable

control of a transport vehicle cooling system. When controlled-atmosphere shipping containers are employed, the oxygen, CO2, ethylene and relative humidity of the produce may also be controlled in real-time or near real-time by employing an on-board computer **232** for controlling ventilation and release of pressurized gases into the interior of the transport vehicle in response to outputs of the sensor assemblies **206**.

During transport, information is collected in the memory. Upon arrival at a buyer's warehouse facility **238** a supervisor can download the information collected in the memory into computer **240** at facility **238**. A comprehensive report on the parameter history of the produce is preferably made available to the supervisor. Such a report may be presented for each packaging unit or alternatively may be summarized and/or averaged for groups of packaging units. It is appreciated that such an arrangement enables a supervisor at the buyer's warehouse facility **238** to monitor the condition of produce being shipped, as indicated at reference numeral **242**, and to schedule shipments to retail outlets as a function of anticipated shelf life of the produce being shipped.

Preferably information regarding various relevant parameters of the produce is retrieved from the memory and stored at computer **240** when the produce arrives at the buyer's warehouse facility **238**, as indicated at reference numeral **244**. Additionally, information regarding various relevant parameters of the produce is collected in the memory during shipment to a retail outlet, as indicated at reference numeral **246**, when it arrives at the retail outlet, as indicated at reference numeral **248**, and until it is removed from the packaging unit, as indicated at reference numeral **250**. As seen with particularly in FIG. **12**, the various produce parameters can also be monitored by a consumer at a consumer facility by simply reading from the memory using a conventional smart card reader, remote readout device or the like. In this way, a consumer can determine whether produce which is being stored continues to be suitable for consumption.

It will be appreciated by persons skilled in the art that the present invention is not limited by what has been particularly shown and described hereinabove. Rather the scope of the invention includes both combinations and sub-combinations of features described hereinabove as well as modifications thereof which would occur to persons skilled in the art upon reading the foregoing description and which are not in the prior art.

The invention claimed is:

1. A system for monitoring parameters of produce comprising:

a plurality of sensor assemblies for sensing at least one parameter of packaged produce at a plurality of times and locations of said packaged produce;

at least one transceiver receiving information relating to said at least one parameter of packaged produce from said plurality of sensor assemblies;

a communications network operative to receive information relating to said at least one parameter of packaged produce at said plurality of times and locations of said packaged produce sensed by multiple sensor assemblies from said at least one transceiver to transmit said information to at least one information receiving location; and

at least one computer at said at least one information receiving location for receiving said information transmitted by said at least one transceiver via said communications network and for providing an information output relating to said at least one parameter of packaged produce at said plurality of times and locations of said packaged produce sensed by multiple sensor assemblies.

2. A system for monitoring parameters of produce according to claim **1** and wherein said communications network is operative to receive and transmit said information in at least near real time to said at least one information receiving location.

3. A system for monitoring parameters of produce according to claim **1** and also comprising at least one parameter controller operative in response to at least part of said information received via said communications network for controlling at least one of said at least one parameter at least one time and location.

4. A system for monitoring parameters of produce according to claim **1** and wherein at least one of said plurality of sensor assemblies is located within a carton containing multiple items of produce.

5. A system for monitoring parameters of produce according to claim **1** and wherein at least one of said plurality of sensor assemblies is located within a retail sales package.

6. A system for monitoring parameters of produce according to claim **1** and wherein at least one of said plurality of sensor assemblies is associated with multiple packages of produce palletized together.

7. A system for monitoring parameters of produce according to claim **1** and wherein at least one of said plurality of sensor assemblies includes functionality for sensing at least one of: temperature, oxygen concentration, CO_2 concentration, ethylene concentration and relative humidity.

8. A system for monitoring parameters of produce according to claim **1** and wherein at least one of said plurality of sensor assemblies includes functionality for sensing at least two of: temperature, oxygen concentration, CO_2 concentration, ethylene concentration and relative humidity.

9. A system for monitoring parameters of produce according to claim **1** and wherein at least one of said plurality of sensor assemblies includes functionality for sensing at least three of: temperature, oxygen concentration, CO_2 concentration, ethylene concentration and relative humidity.

10. A system for monitoring parameters of produce according to claim **3** and wherein said at least one parameter controller comprises a vacuum cooling controller and wherein said system is operative to govern vacuum cooling operation based at least on sensed weight loss of said produce.

11. A system for monitoring parameters of produce according to claim **3** and wherein said at least one parameter controller comprises a cooling controller and wherein said system is operative to govern cooling operation based at least on sensed temperature.

12. A system for monitoring parameters of produce according to claim **3** and wherein said at least one parameter controller comprises a humidity controller and wherein said system is operative to govern humidity control operation based at least on sensed humidity.

13. A system for monitoring parameters of produce according to claim **3** and wherein said at least one parameter controller comprises a temperature controller and wherein said system is operative to govern temperature control operation based at least on sensed temperature.

14. A system for monitoring parameters of produce according to claim **3** and wherein said at least one parameter controller comprises a gas concentration controller and wherein said system is operative to govern gas concentration control operation based at least on sensed gas concentration.

15. A system for monitoring parameters of produce according to claim 14 and wherein said gas concentration is a concentration of at least one of oxygen, CO_2 and ethylene.

16. A system for monitoring parameters of produce according to claim 1 and wherein said produce includes at least one of milk products, fruits and vegetables.

17. A system for monitoring parameters of produce according to claim 1 and wherein at least one of said plurality of sensor assemblies senses at least one parameter of packaged produce at locations of said packaged produce including at least one of a produce harvesting location, a produce cooling location, a produce transporting location, a buyer's warehouse and a retail location.

18. A system for monitoring parameters of produce according to claim 1 and wherein at least one of said plurality of sensor assemblies senses at least one parameter of packaged produce at locations of said packaged produce including at least two of a produce harvesting location, a produce cooling location, a produce transporting location, a buyer's warehouse and a retail location.

19. A system for monitoring parameters of produce according to claim 1 and wherein at least one of said plurality of sensor assemblies is located within a modified-atmosphere enclosure enclosing said produce.

20. A system for monitoring parameters of produce according to claim 1 and wherein at least one of said plurality of sensor assemblies is located outside a modified-atmosphere enclosure enclosing said produce.

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